Net primary productivity of macrophyte communities in the experimental marshes after twelve growing seasons

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Introduction

Direct measurements of macrophyte net primary productivity (NPP) were first made at the experimental wetland basins of the Olentangy River Wetland Research Park (ORWRP) in 1997. This study in 2005 represents the ninth set of such measurements. Prior to 1997 (the fourth growing season), macrophyte harvesting for estimation of biomass was not considered a good option as vegetation was just getting established in the basins.

Methods

Aboveground net primary productivity (NPP) was estimated by harvesting peak biomass at the end of the growing season on August 3, 2005 at selected stations in the two experimental wetland basins at the ORWRP (Figure 1). The biomass harvesting stations that are used each year were established in 1997 along the permanent boardwalk system (Mitsch and Bouchard, 1998). To avoid harvesting plants from the exact same spots from one year to the next, 1-m^2 PVC sampling frames are tossed randomly from the boardwalks into the vegetation. These 1-m^2 frames are used to delineate quadrats in which vegetation is harvested. While there are potentially 22 stations in each wetland, a maximum of 16 sites are harvested annually in each basin, and stations lacking emergent vegetation are skipped. Fifteen quadrats were sampled in Wetland 1 (W1) and eight quadrats were sampled in Wetland 2 (W2). Eight out of a possible eight plots were sampled in the northern half (inflow area) of W2, but no plots in the southern half of W2 were sampled. Vegetation in the outflow of W2 remains sparse since extensive herbivory occurred during 2002.

In each quadrat, plants were clipped at ground level (the water was lowered in the wetlands to facilitate sampling). Samples were segregated both by quadrat and by species, placed in plastic bags and weighed in the field with a hanging balance (accuracy ± 40 g). Sub-samples were taken to the laboratory where both wet weight and dry weight (dried at 105°F for 48 hours) were determined to estimate dry/wet ratios. Average ratios for each species were multiplied by the total wet weight of that species in each quadrat to estimate total dry weight production. The sum of all species in a quadrat was the estimated peak biomass, and hence annual aboveground net primary productivity (NPP).

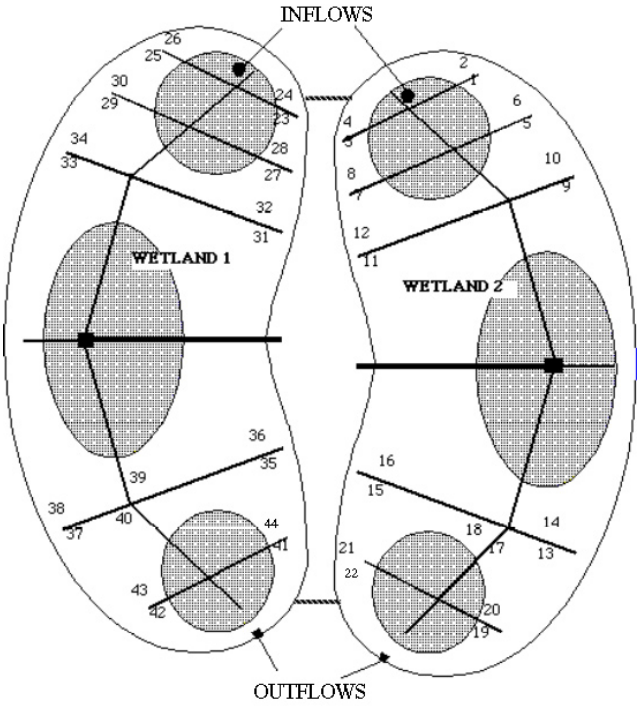

Figure 1. Potential sampling stations for macrophyte harvesting. Fifteen stations were sampled in Wetland 1 and eight in Wetland 2 in 2005 as there was little macrophyte vegetation in the southern half of Wetland 2 in 2005.

Results and Discussion

Comparison of Basins and Location

In 2005, macrophyte aboveground NPP was 697 ± 97 g m^{-2} yr^{-1} for the 15 sites in W1, and 890 ± 159 g m^{-2} yr^{-1} for 8 sites in W2. Productivity was similar at the inflow in the two wetlnds but quite dissimilar in the outflow halves of the wetlands (Figure 2). There continued to be essentially no emergent vegetation in the outflow area of W2 (see vegetation cover chapter). If the inflow and outflow areas are considered together, there was considerably more biomass in W1 than in W2 in 2005.

Dry/Wet Ratios

As discussed in previous annual reports, dry/wet ratios of individual plant species that are necessary for estimating NPP are provided (Table 2). Dry/wet ratios were determined for the dominant species found in 2005 in both wetlands.

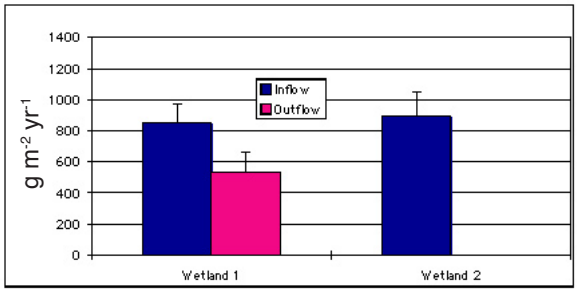

Figure 2. Aboveground net primary productivity in Wetlands 1 and 2 inflow and outflow areas for 2005.

Table 1. Estimated net above-ground primary productivity (NPP) of macrophyte communities in the experimental wetlands based on peak biomass harvest, 1999-2005. Numbers are avg ± std error [# samples].

Wetland/ Year	Total NPP, g m^{-2} yr^{-1}	Inflow NPP, g m^{-2} yr^{-1}	Outflow NPP, g m^{-2} yr^{-1}
Wetland 1			
1999	657±76 [16]	601±126 [8]	714±90 [8]
2000	482±64 [16]	597±87 [8]	368±79 [8]
2001	393±87 [9]	454±98 [7]	181±120 [2]
2002	689±93 [16]	915±126 [8]	462±79 [8]
2003	432±60 [16]	570±90 [8]	295±45 [8]
2004	408±37 [15]	441±59 [8]	369±41 [7]
2005	697±97 (15)	844±126 (8)	529±131 (7)
Wetland 2			
1999	1023±94 [16]	790±75 [8]	1256±130 [8]
2000	1013±105 [16]	882±126 [8]	1144±163 [8]
2001	832±85 [9]	746±76 [7]	1134±145 [2]
2002	519±64 [15]	699±84 [7]	361±53 [8]
2003	192±54 [10]	226±62 [8]	54±19 [2]
2004	586±91 [10]	583±92 [8]	596±361 [2]
2005	890±159 (8)	890±159 (8)	0,00±0.00 (0)

Comparison with Previous Years

Macrophyte productivity in W1 and the nothern half of W2 in 2005 was higher than the productivity in similar areas in 2004, supposedly due to the steady water level maintained in 2005 compared to the flood pulsing hydrology in 2004 (Figure 3). NPP, on a plot-by-plot basis, was significantly higher in W2 compared to W1 for four years, from 1998 to 2001. In 2005, NPP was higher in W1 than W2 ($p = 0.027$) when sites were paired in the two wetlands.

Species Dominating NPP

Macrophyte species found in sample quadrats in 2003 -2005 are listed in Table 3. As was the case in previous years, the species harvested in the two wetlands indicate certain differences that can still be attributed to the original 1994 planting. Three of the 12 species

Table 2. Dry/wet ratios (avg ± std error (# samples)) of dominant macrophyte species in the experimental wetlands from 2001-2005.

Species/	Wetland 1	Wetland 2
Schoenoplectus tabernaemontani		
2002	0.15±0.01 (14)	0.16±0.02 (14)
2003	0.16±0.01 (14)	0.05±0.01 (7)
2004	0.19±0.01 (14)	
2005	0.23±0.02 (13)	0.20±0.01 (6)
Polygonum sp.		
2002	0.16±0.01 (13)	0.15±0.01 (7)
Scirpus fluviatilis		
2001	na	na
2002	0.13±0.03 (3)	na
2004	0.34±0.0 (2)	na
2005	0.15 (1)	na
Sagittaria latifolia		
2002	0.07±0.01 (3)	na
2004	0.22 (1)	na
Sparganium eurycarpum		
2001	0.16±0.03 (7)	na
2002	0.10±0.01 (10)	na
2003	0.15±0.01 (15)	na
2004	0.17±0.01 (16)	na
2005	0.27±0.02 (15)	na
Typha spp.		
2001	0.20±0.05 (2)	0.29±0.03 (9)
2002	0.14±0.03 (4)	0.21±0.04 (8)
2003	0.23±0.02 (5)	0.11±0.00 (3)
2004	0.21±0.02 (4)	
2005	0.28±0.05 (7)	0.21±0.01 (4)
Leersia oryzoides		
2002	0.25±0.03 (10)	0.23 ± 0.02 (4)
2003	0.21±0.2 (15)	0.10±0.02 (6)
2004	0.27±0.03 (13)	
2005	0.37±0.06 (12)	0.26±0.06 (4)
Cyperus sp.		
2002	0.15±0.01 (8)	0.21±0.02 (9)
Echinochloa sp.		
2002	0.13 ±0.03 (5)	0.17±0.04 (2)
Lycopus americanus		
2002	0.18±0.01 (2)	na
Ludwigia sp.		
2003	na	0.14±0.4 (2)
Alisma plantago		
2004	0.035 (1)	

planted in W1 (*Schoenoplectus tabernaemontani*, *Sparganium eurycarpum,* and *Scirpus fluviatalis)* were still contributing to macrophyte productivity from 2003-2005. *S. tabernaemontani* contributed 23% of the productivity in W1 and *Sparganium eurycarpum* added 27% of the productivity in 2005 (Table 3) similar to the pattern in 2004. The naturally colonizing species *Typha* and *Leersia* were more significant in 2005, contributing 29 and 19% of the productivity in W1, respectively.

S. tabernaemontani, which had reestablished from the seedbank in W2 during spring drawdown in 2001, continued

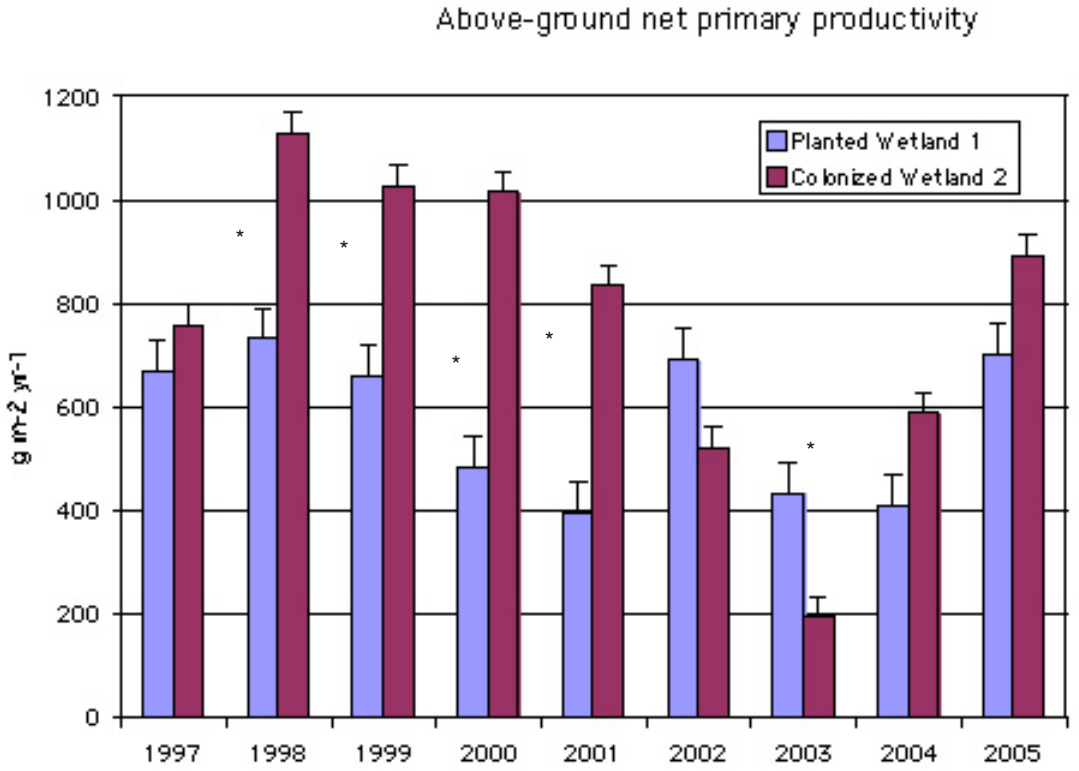

Figure 3. Aboveground net primary productivity for 1997-2005 in the experimental wetlands. * indicates significant differences between the two wetlands ($\alpha = 0.05$).

Table 3. Percent dominance of macrophytes according to aboveground primary productivity in quadrats in 2003 (n = 16 for W1; n = 10 for W2), 2004 (n = 15 for W1; n = 10 for W2), and 2005 (n = 15 for W1; n = 8 for W2) and species richness in quadrats. 0.0 indicates species was present but did not contribute significantly to productivity.

	2003 pulsing		2004 pulsing		2005 steady-flow	
Species	W1	W2	W1	W2	W1	W2
Schoenoplectus t.,	36.7	37.3	33.8	38.1	22.9	35.9
Polygonum spp.	0.0	0.0	0.0			
Typha spp.	16.3	41.9	11.5	57.2	29.4	56.6
Sparganium eury.	18.0		26.4		26.9	
Leersia oryzoides	28.2	25.3	22.5	4.7	19.4	7.5
Cyperus sp.	0.0					
Echinochloa	0.0					
Panicum sp.		5.6				
Scirpus fluviatilis	0.9		5.3		1.4	
Sagittaria latifolia	0.0		0.5			
Ludwigia palustris						0.0
Penthorum sedoides		0.0				
Gratiola virginiana		0.0				
Mimulus ringens	0.0					
Alisma plantago			0.0			
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0
Species richness	10	7	8	3	5	4

to account for about one-third of the productivity in W2 (36% of the productivity in 2005, 38% of the productivity in 2004, and 37% of its productivity in 2003). *Typha* again dominated NPP in W2 with 57% of the productivity in 2005, the same as in 2004. By contrast, *Typha* contributed 41% of the productivity in W1 and 100% of the productivity in W2 in 2001, but lost dominance in both wetlands as a result of muskrat herbivory in winter 2001, followed by seedbank regeneration and subsequent agressive growth by *Schoenoplectus* in 2002.

There were five macrophyte species found in sampling plots in W1, and four species in W2, in 2005. By comparison, ten and seven species were found in 2003, and 11 and 10 species in 2002 in W1 and W2, respectively. Smartweed *(Polygonum* spp.) continued to be found in both wetlands in 2005, although it did not contribute significantly to NPP. In 2004, *Polygonum* spp. was found only in W 1. This is a considerable decline from 2002, when it contributed 12 and 22% of the productivity, respectively to W 1 and W2.

Basin Productivity

Based on the aboveground productivity estimates reported here, and on estimates of macrophyte cover presented elsewhere in this annual report (Mitsch et al., 2005; W1 = 5898 m^2; W2 = 3339 m^2), aboveground productivity of macrophytes was estimated to be 4111 and 2949 kg yr^{-1} in W1 and W2, respectively (Table 4). Overall NPP increased 69% in W1, and 39 % in W2, from 2004 to 2005. The year 2005 is the fourth year in a row in which the planted W1 had a higher esimated macrophyte carbon sequestration than the naturally colonized W2. The cumulative organic matter production by macrophytes over the last nine years is now almost equal in the two wetlands (~25,000 - 28,000 kg $basin^{-1}$) (Table 4).

Table 4. Estimated macrophyte above-ground net primary productivity in each experimental wetland, 1997-2005 (kg dry-wt per wetland basin).

Year	Wetland 1	Wetland 2
2005	4,111	2,949
2004	2,434	2,122
2003	2,397	625
2002	4,478	3,330
2001	963	1,250
2000	1,960	4,265
1999	5,800	6,800
1998	3,300	3,500
1997	2,525	3,040
Total	24,968	27,881

References

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